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MINERAL INVESTIGATIONS BETWEEN KHAMIS MUSHAYT AND BI'RIDIMAH, SAUDI ARABIA

by

William C. Overstreet 1919-
Courtney

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1. Geological literature on the San Joaquin Valley of California, by J. C. Maher and W. W. Trollman. 421 p., 2 figs. 504 Custom House, San Francisco, Calif. 94111; 7638 Federal Bldg., Los Angeles, Calif. 90012; 602 Thomas Bldg., Dallas, Texas 75202.

2. Preliminary geologic map of the Great Falls-Browns Lake area, northwestern Montana, by Melville R. Mudge. 1 map, explanation (2 pieces), and 3 data sheets. Scale, 1:250,000. 1012 Federal Bldg., Denver, Colo. 80202; 8102 Federal Office Bldg., Salt Lake City, Utah 84111; 678 U.S.Court House Bldg., Spokane, Wash. 99201; 510 First Ave. North, Great Falls, Mont. 59401; and Montana Bureau of Mines and Geology, Montana School of Mineral Science and Technology, Butte, Mont. 59701. Material from which copy can be made at private expense is available in the Spokane office.

3. Mineral investigations between Khamis Mushayt and Bi'r Idimah, Saudi Arabia, by William C. Overstreet. 15 p., 3 p. tabular material.

4. Preliminary report of a mineral reconnaissance in the Al Maddah-Harfayn area, Asir quadrangle, Saudi Arabia, by Jesse W. Whitlow. 4 p., 2 figs.

5. Report on allanite occurrence near Hamdtha on Wadi Tathlith, Saudi Arabia, by Glen F. Brown. 2 p.

6. Mineral exploration between Bi'r Idimah and Wadi Haraman, Asir quadrangle, Saudi Arabia, by William C. Overstreet. 70 p., 11 tables.

7. Preliminary results of a trip October 30-December 21, 1965, to the area between Sha'ya and Jabal Bani Bisqan, Saudi Arabia, together with a synopsis of mineral reconnaissance in the Asir quadrangle, by William C, Overstreet. 48 p., 9 tables.

8. Summary of results from a trip February 6-March 5, 1966, to Bi'r Idimah, Jabal Ashirah, and As Sarat Mountains, Saudi Arabia, by William C. Overstreet. 47 p., 1 fig., 6 tables.

PREFACE

In 1963, in response to a request from the Ministry of Petroleum and Mineral Resources, the Saudi Arabian Government and the U. S. Geological Survey, U. S. Department of the Interior, with the approval of the U. S. Department of State, undertook a joint and cooperative effort to map and evaluate the mineral potential of central and western Saudi Arabia. The results of this program are being released in USGS open files in the United States and are also available in the Library of the Ministry of Petroleum and Mineral Resources. Also on open file in that office is a large amount of material, in the form of unpublished manuscripts, maps, field notes, drill logs, annotated aerial photographs, etc., that has resulted from other previous geologic work by Saudi Arabian government agencies. The Government of Saudi Arabia makes this information available to interested persons, and has set up a liberal mining code which is included in "Mineral Resources of Saudi Arabia, a Guide for Investment and Development," published in 1965 as Bulletin 1 of the Ministry of Petroleum and Mineral Resources, Directorate General of Mineral Resources, Jiddah, Saudi Arabia.

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Saudi Arabian Mineral Exploration - 23

MINERAL INVESTIGATIONS BETWEEN KHAMIS MUSHAYT AND BI'R IDIMAH, SAUDI ARABIA

by

William C. Overstreet

Introduction

Mineral investigations between Khamis Mushayt and Bi'r Idimah in the Asir quadrangle, sheet I-217 (Brown and Jackson, 1959) began September 24, 1964 and ended November 20. Total distance travelled was 6264 kilometers. Sixteen camps were set, and 483 samples of various geologic materials, principally wadi sands, laterite, and gossan, were taken. Not all the area originally scheduled to be covered was examined, owing principally to more time being spent on scheelite and laterite than originally planned. No work was done in the area covered by the two 1:50,000 mosaics numbered 9E and 8E. They will be blocked out in January 1965.

The area completed includes parts or all of the 1:50,000 scale mosaics numbered 8B, 8C, 8D, 8F, 9B, 9C, 9D, and 9F. No megascopic indication of an exploitable mineral deposit of any type, except the small occurrences of marble cited in the October 1964 report and slate already in use, was discovered. A previously unknown ancient working was found, but it is small. Unless spectrochemical analysis of samples discloses anomalously great amounts of some element, the area examined must be considered as unfavorable for ore deposits, except possibly the gossan exposed south of Bi'r Idimah.

Scheelite

The scheelite occurrences leading southward from Bishah into the work area have a sharply defined western boundary and play out to the south in mosaic 8C.

These occurrences also have a sharp eastern edge in the same mosaic. The occurrences are for the most part in amphibolite schist (unit sa) and complexly intermixed granite, diorite, gabbro, and amphibolite (unit c). The unit gp, per-alkalic granitic rock, particularly where it is in contact with basic rocks of unit bu, had been thought by me to be an especially favorable host for scheelite; therefore, attention was given the problem in mosaics 8F and 9F, where a large contact zone exists between these units in the eastern part of the map. All the rocks are devoid of scheelite including all phases of such strikingly zoned plutons as Jabal Ashirah, which has a quartz porphyry core containing inclusions of the outer zones of biotite granite, hornblende granite, and syenite. Because exposures representing about 25 percent of the mapped area of unit bu intruded by unit gp have been examined and no scheelite was found, it is thought now that the remainder of the area is also likely to be barren of this mineral.

Chromite, magnesite, and asbestos

There is a break in the character of the rocks shown as bu along the eastern part of the map at Wadi Mirah southeast of the Higera asbestos mine. From Wadi Mirah southward to Jabal Ashirah the bu unit consists largely of extrusive basic rocks of andesitic character or near surface intrusives of dioritic or gabbroic affinity. No ultra-basic rock nor serpentinites were seen. The bu unit in that area is unlikely to be a source for chromite, platinum, nickel, magnesite or asbestos. North of Wadi Mirah some ultrabasic rocks begin to appear in the unit and serpentinites are present. More asbestos than the display at the Higera mine might be found between the Higera mine and Wadi Hulaymah to the north. No magnesite was observed, nor was chromite seen. If either of these minerals is present it must be well north of the Higera mine. The southern part of the bu unit in sheet I-217 resembles units m, a, and as in sheet I-212, (Bramkamp, Gierhart, Brown, and Jackson, 1956), where ultrabasic rocks actually make up only a very small part of a thick sequence of extrusive and shallow intrusive mafic rocks. However, in sheet I-212 graywacke was found associated with the volcanic rocks, but it is absent, or largely absent, in the mafic rocks south of the Higera mine. The sc unit (sericite-chlorite schist) of sheet I-217 south of Bi'r Idimah may be the equivalent of the graywacke exposed in the area of sheet I-212 and thus be younger than the position assigned to it on sheet I-217, but convincing evidence to support this relation was not found.

Magnetite, pyrrhotite, and pyrite circular plutons

The circular plutons of per-alkalic granitic rock (gp unit), as represented by Jabal Ashirah, have an outer shell of syenite and quartz syenite. The possibility exists that this syenite is really fenitized wall rock biotite granite gneiss, but I didn't find either the rimmed feldspars or the alkali pyroxenes common in fenite. Nevertheless, a search was made for carbonatite dikes and strontium and barium minerals in the outer shell and wall of the pluton, but none was found. West and northwest of Jabal Ashirah, in mosaics 8E and 9E, two circular plutons are shown on sheet I-217 as having partial rims of unit a amphibolite. Neither pluton was visited but on the next trip these amphibolite rims must be examined for possible concentrations of magnetite, pyrrhotite, and pyrite. It seems quite possible that the rim of amphibolite is one of the differentiation products of the pluton. If it is, and if the outer walls of the pluton are syenite instead of fenite, then a possibility of magnetite and pyrrhotite bodies exists.

Faults

The alteration zones reported by G. F. Brown (oral communication, 1964) in the north-trending fault in the western part of mosaic 9F may be the weathered, pyrite-impregnated tectonic slices of sericite schist, and weathered pyrite-impregnated felsite dikes which crop out sporadically in the wadi. Vivid colors are formed by the iron oxides, but no copper stains are present.

The nearly east-trending jasper fissure filling and associated white quartz boxwork seen south of Khamis Mushayt and mentioned in my monthly report for October is part of a system of more or less east-trending fractures which are variously filled with red rhyolite, red felsite, jasper or quartz and which are not very common south of Khamis Mushayt. They can be seen on the aerial photographs, but they have to be individually inspected to determine their composition. Most are unmineralized felsite and rhyolite. A very few are brecciated, pyrite-impregnated and silicified rhyolite dikes. One of these has a small gossan. Only one of the features proved to be jasper. No copper stain or ancient workings are associated with them. In mosaic 9D a great swarm of more or less east-trending dikes are present well to the east of the pyrite-bearing fractures south of Khamis Mushayt. Although the eastern dikes maintain the strike and dip of the felsic dikes south of Khamis Mushayt, they are a later system of unmineralized epidiorite and phonolite dikes.

Gossan

A large gossan is crossed by the Bishah-Najran highway at a point 20 km by road south of Bi'r Idimah. There is no doubt that this is the locality G. F. Brown (written communication, 1964) reported as being 12 km south of the well. The gossan is very conspicuous. Lengthy parts of the road are on it. Vehicular traffic has crushed the hematite and limonite of the gossan and produced great patches of vermillion, maroon, and brown dust. The gossan caps a number of hills forming a southward opening arc where the road crosses it. The west end of the arc turns westward and the east end extends southward. Along this arc the gossan is intermittently exposed for at least 5 km. Much of the area of the gossan is, however, not underlain by the pyrite-bearing chalcedony, rhyolite, and felsite from which the gossan was derived. Iron oxides have moved downslope in groundwater and surface runoff. They have precipitated over all the different rocks in the area, including wadi sand, gravel, and carbonate deposits. In fact, probably three-fourths of the total exposed area of the gossan is over unmineralized rocks. The iron oxides of the gossan formed from pyrite. No other sulfide mineral than pyrite appears to be present in the area: megascopic evidence of copper, lead, or zinc was lacking.

The area of the gossan is underlain by andesite porphyry and greenstone intruded, in sequence, by diorite, massive pink biotite granite, felsite, rhyolite, and dacite porphyry. Brecciated zones in all rocks except dacite are filled with pyrite-bearing fine-grained massive gray quartz or chalcedony in the central part of the gossan, and by pyrite-bearing felsite and rhyolite in the arcuate limbs of the gossan. By far the largest part of the gossan is derived from felsite and rhyolite containing 1 to 3 percent of disseminated pyrite. The silicified brecciated zones in the central part of the gossan may contain as much as 7 percent of pyrite. No true veins of any sort were seen; however, weathering of the pyrite has caused iron-bearing groundwater to move out into joints in the rocks around the pyritiferous breccia and dikes, and hematite precipitated from this surface water has filled the joints giving structures with superficial resemblance to weathered veins. Where the silicified fracture zones can be seen (few such places were found because of the cover of hematite and limonite), the zones were 0.6 to 10 m thick, but their lengths are indeterminant without plane table mapping. They are developed in two directions: about N. to N.10°W. dipping from 60°W. to vertical and N.60°E. dipping 50°W., of which they northerly trending zone is the best developed and is the one in which the pyritiferous felsite and rhyolite dikes are emplaced. Intersection of these two directions of strike are at least partly responsibile for the arcuate plan of the gossan. Many rhyolite and felsite dikes with less than 1 percent of pyrite and having sparse hematitic stain persist in north-trending zones up to 10 km north of the gossan, and in north-trending zones up to 8 km east of the gossan.

This gossan does not appear to possess any greater potential for an ore deposit than the three large areas of pyritiferous sericite schist north of Abha and west of Khamis Mushayt reported in October, but the spectacular gossan is quite unlike anything seen to the west although schists and phyllites on the Abha-Faya road contain more pyrite than the chalcedony, rhyolite, and felsite at the gossan south of Bi'r Idimah. Probably the extensive gossan developed south of Bi'r Idimah, and none formed between Abha and Faya, because erosion is slower in the Bi'r Idimah area.

Samples of gossan material were taken for analysis. Until results of laboratory tests are at hand the gossan cannot be dismissed. The ancient residents of the area must certainly have tested these conspicuous outcrops and found them lean in or devoid of gold. The gossan occurs on a principal and probably historic route of travel, but no ancient workings are in it. *

* Results of analyses made July 1, 1965, on material from the gossan are tabulated below. The low abundances of copper, lead, and zinc, combined with the consistent presence of cobalt, chromium, and nickel, the anomalously high quantities of molybdenum, and the presence of traces of tin are tentatively interpreted to mean that the gossan have formed from high-temperature sulfide minerals, probably pyrite and pyrrhotite. Further study and drilling are needed to evaluate this large gossan, possibly the largest in Saudi Arabia.

Sample number	7976	7977	7978	7979	7980	7981	7982	7983	7984
B	< 10	< 10	< 10	15	< 10	10	10	10	10
Ba	500	300	200	500	200	100	300	70	100
Co	20	20	30	15	30	30	50	30	50
Cr	200	100	100	150	70	50	100	50	70
Cu	10	20	20	10	30	50	20	10	30
Ga	10	10	15	10	10	10	30	10	15
La	-	-	-	20	-	-	-	-	-
Mn	700	300	200	500	100	100	100	100	200
Mo	5	7	15	< 2	20	10	15	10	15
Ni	10	15	10	10	7	5	7	7	10
Pb	< 10	-	-	15	-	-	-	-	-
Sc	20	10	10	10	< 10	< 10	< 10	< 10	< 10
Sn	< 10	-	10	< 10	10	10	10	10	10
Sr	200	150	< 20	200	< 20	20	50	20	20
Ti	3000	2000	1500	2000	1500	1000	700	2000	1000
V	70	70	100	50	150	50	50	100	50
Y	10	10	< 10	15	< 10	-	-	-	-
Zn	< 100	-	150	-	100	100	150	100	150
Zr	70	50	50	100	70	30	30	50	50
Hg	n.d.	8	19	8	50	14	< 2	14	25

Sample number	7985	7986	7987	7988	7989	7990	7991	7992	7993
B	< 10	20	10	<10	10	<10	<10	15	20
Ba	100	700	300	70	300	100	300	700	500
Co	30	30	30	30	30	50	30	20	20
Cr	100	150	100	10	100	50	100	70	200
Cu	15	150	15	15	20	15	20	30	20
Ga	10	10	10	10	10	15	10	10	10
La	-	-	-	-	-	-	-	-	-
Mn	200	200	500	50	500	200	300	200	500
Mo	10	2	7	15	7	15	10	3	2
Ni	5	30	10	7	15	10	20	10	20
Pb	-	20	-	-	-	-	-	20	10
Sc	10	20	10	< 10	10	<10	<10	10	15
Sn	10	<10	<10	10	<10	10	10	< 10	<10
Sr	150	300	150	<20	200	20	150	150	200
Ti	2000	2000	2000	1500	1000	500	1700	1500	1500
V	70	70	70	50	50	50	150	50	100
Y	-	10	10	-	10	-	10	15	10
Zn	150	-	100	-	-	100	100	[illegible]	-
Zr	70	70	30	30	50	30	50	150	100
Hg	7	4	8	36	11	2	6	n.d.	10

Semi-quantitative spectrographic analyses by C. E. Thompson, July 1, 1965.

Mercury determined by atomic absorption technique by C. E. Thompson, July 15, 1965.

7976 - 7985	Gossan
7986	Pyritiferous silicified rhyolite
7989 - 7990	Silicified contact between granite and diorite
7991 - 7992	Pyritiferous chert replacing andesite
7993	Wadi sand from spessartite-bearing rhyolite dikes in greenstone

Laterite and sedimentary clay

The laterite deposits of the As Sarat are the largest mineralized area I have seen since I began work in Arabia, but no part of the laterite constitutes an ore for iron, aluminum, nickel, or clay. The materials collected by Goudarzi for analysis, and the results of the analyses, seem to me to be sufficiently representative so that additional detailed work need not be done to evaluate the deposit for iron and aluminum. Samples we collected should be enough for the objectives of this project. The laterite area itself, however, well deserves detailed study at some later date on its scientific merits alone, because it is a remarkably exposed weathered zone.

The iron deposits are ferruginous concretionary laterite and ferruginous conglomerate. The ferruginous laterite represents a concentration of iron in the upper part of the weathering profile. It is only present in the top part of laterites formed on granodiorite, diorite, gabbro, and hornblende schist. The thickest sections of the ferruginous concretionary laterite reach about 10 meters, and are preserved unconformably under basalt, the base of which is also weathered. Some ferruginous concretionary laterite is preserved as a thin veneer where the basalt is eroded, and the ferruginous laterite itself forms a hard cap preserving small knobs of laterite and saprolite. The ferruginous conglomerate fills channels in the upper surface of the ferruginous concretionary laterite and forms sheets of slope-wash that emerge from under the basalt and extend downslope in ancient to Recent valleys. These conglomerates contain quartz pebbles, clay balls, and iron concretions. They form by the precipitation of iron from groundwater moving downslope. These ferruginous conglomerates quite commonly unconformably overlie non-ferruginous laterite formed on felsic rocks like sericite schist, graphite schist, granite, rhyolite, schistose rhyolite, and argillite. The spread of these ferruginous conglomerates over laterite formed on felsic rocks gives the appearance of a greater amount of iron laterite than actually exists.

Great thicknesses of ferruginous laterite are not to be expected because the probable method of formation by precipitation of iron from upward moving groundwater restricts development to a few tens of meters vertically, and, indeed, thicknesses greater than 10 meters were not observed. The ferruginous laterite contains much megascopically identifiable silica in the form of quartz and clay. At no locality visited was a quartz-free strongly differentiated laterite found which could serve as iron ore. It would be possible to select specimens of ferruginous laterite, and especially ferruginous conglomerate, that contain 50-55 percent Fe_2O_3, but these would be far from representative. Most of the ferruginous laterite and conglomerate contains between 25 and 35 percent of Fe_2O_3 with high percentages of Al_2O_3 and SiO_2 as clay and quartz. There is no locality in the As Sarat area north of latitude 18°N. that is a workable deposit of iron ore. Inasmuch as that is 50 percent of the area of laterite, and the conditions causing the formation of laterite are related to climate, the laterite south of latitude 18°N. is not expected to contain workable iron ore.

Bauxite was not found although clay-ball conglomerate resembling pisolitic bauxite occurs quite commonly in the channel-filling and slope-wash conglomerates unconformably overlying the laterite. Such clay-ball conglomerates are red to maroon where they are associated with ferruginous laterite and white, buff, or light gray where they formed on non-ferruginous laterite. Rarely, joints in the laterite are filled with clay-ball conglomerate. The constant presence of large amounts of silica in the laterite in the form of euhedral quartz crystals, quartz blebs, thin quartz veins, and finely dispersed chalcedonic quartz is very unfavorable for the development of bauxite. Even if it is postulated that bauxite formed at a part of the weathering profile removed now by erosion (a condition which probably did not take place), and that detrital bauxite filled channels in the old weathering surface, such bauxite would have reverted to kaolinite because of the large amounts of silica moving in the zone of weathering. Even the clay-ball conglomerates cannot be regarded as detrital bauxite changed to kaolinite, because too much quartz is in the conglomerate for the clay-balls ever to have been pisolitic bauxite. Thus, there is no possibility of detrital bauxite in depressions on the old lateritic land surface. The area is not a source for bauxite.

Much of the laterite consists of mixtures of kaolinite and quartz with no quartz-free high-grade residual kaolinite present. At several places a very fine-grained gray to buff material breaking with conchoidal fracture was observed.

It closely resembles flint clay (used in manufacture of refractories), but it seems a little too hard. DTA examination will reveal if this is flint clay, which is a very pure form of kaolinite, or if it is a mixture of clay and silica, which it most likely is. In channels and in recently dissected, previously filled valleys, deposits of sedimentary clay are present. For the most part the clay is iron stained and contains variable amounts of detrital quartz. One body of splendid white sedimentary kaolinite was found, but the clay contained much quartz, and the body occupied no more than 400 cubic meters. Doubtless many small deposits of sedimentary kaolinite are present in the area, the more quartz-free ones of which could be used for local manufacture of pottery as a cottage industry, but large sedimentary or residual kaolinite deposits of ceramic grade are lacking.

If a source for calcium carbonate were found close to the As Sarat laterite area, it is possible that the calcium carbonate could be blended with the laterite to make cement. Marble or limestone was not in the area.

The most mafic rocks over which the laterite formed are gabbro. To judge by the color of this laterite, it is not nickeliferous.

The feldspathoidal syenite (unit Tfs) was visited and about 50 pounds of the rock was collected for age determination. The relations of the main mass of syenite to the laterite and basalt are still uncertain. Several biotitic dikes were found in the basalt. They will have to be studied in thin section to see if they are related to the syenite or to the basalt. If they are syenitic, then there is no question that the main syenite is also intrusive into the basalt.

Sedimentary clay in large quantity is present along the Bishah-Najran road between the Higera Mine and the village of Hamdah. This material does not seem suitable for ceramic use because the clay, to judge from the drying characteristics of thin beds, is a mixture of kaolinite, montmorillonite and illite. The last two components shrink so badly on drying and firing that even though they improve the plasticity of the kaolinite with which they are mixed, they spoil its usefulness for the manufacture of ceramic pieces. The different clays cannot be separated. The clay would probably not be useful even for cottage industry pottery because of shrinkage. Doubtless it can be used for air-dried bricks.

Gold

A small ancient working was shown to me by Salem, a former driver for the Ministry now living in the Jabal Ashirah area, who stated the opening was unknown to the Ministry. It is not shown on sheet I-217, nor is it described among the mine reports covering the area of sheet I-217. The ancient working is 12 km west-northwest of Jabal Ashirah. It is locally known as El Ergun. In its present condition El Ergun consists of an open trench 2-4 m wide, 20 m long and 0.5 m deep which explored a vein of white quartz striking N.30°E. and possibly 0.3 m thick by 20 m long. Nearby are the probable remains of two or three ancient houses now much reworked by Bedouin, but there are no slag piles. Very little ore appears to have been taken from the trench: only about 0.75 ton of quartz tailings are present, and waste rock on the dump, estimated at 30 to 40 tons, accounts for most of the rock removed. The ancient working could be classed as a prospect. Wall rock is coarse-grained biotite granite gneiss with foliation striking N.30°E. vertical. A phonolite sill intrudes the gneiss and for a few meters forms the northeastern wall of the vein. The phonolite is chloritized and limonitized for 6 m at the northern end of the vein, but the alteration is not intense. The southern end of the quartz vein closes against a dike of andesite porphyry which strikes N.60°E. vertical and is cut by the phonolite. The vein lies in the northwest quadrant formed by the dike and sill, and is sub-parallel to the phonolite sill. The vein consists of white massive quartz with sparse scattered pyrite crystals altered to limonite. Some joints and fractures are thinly stained by limonite, but the quartz is not heavily stained. The vein does not contain other sulfide minerals.

Other and similar dike intersections can be seen on aerial photographs of this area, and they may also have auriferous quartz veins nearby, but they were not examined on the ground because of the poor showing made by this prospect. The local guide Salem reported another ancient working of similar size as being 7 km to the north, but it could not be found on the ground or on the photographs, even with the guide's help.

Large north-trending and northwest-trending faults are present in area examined. The north-trending faults show some mineralization, principally enrichment in pyrite without copper, but the northwest-trending faults are essentially devoid of mineralization. In this area the little mineralization present occurs mainly in schists and amphibolite.

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